# EVALUATION OF SETTLEMENT DUE TO LIFT BEHAVIOR AT AIRPORT RUNWAY STRIP IN PENINSULAR MALAYSIA

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**DEDICATION**

For both my parents; Sarifah Hassan and Abu Bakar Hassan.
Who always love me as their own.
Unconditional love does exist.
And that is, both of you.

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With humble heart, I would like to extend my gratitude to Allah SWT for the opportunity furthering my master's degree. Strongest yet warmest support system from both my parents, the sleepless night, to no-weekend-dinner spent together. I owe both of you my life. For unending support and trust from my supervisor Dr. Mohd Khairul Idham, to my Superior in Dynatest, Wan Shaqirah for the continuous motivating insightful pep talks. Really everyone who helped me along the way with opinions and ideas. Also, to the fellow postgraduate course mates, Latifah Nasir, Amiliah and Mohd Syahrir. Truly, it means the world to have all of you in this journey. May Allah SWT bless.

## ABSTRACT

The purpose of this study is to predict soil strength at runway strip to have within the designated CBR values. According to Aerodrome Design Manual (Doc 9157 AN/901A) by International Civil Aviation Organization (ICAO), there are loopholes in going further than 15 cm below and it is only describing CBR strength but not the implication to the ground of having such CBR values. Airports all over the world are doing the same applications in gathering information of their runway strips. Innately, preventive maintenance program will be introduced to mitigate soil strength improvement issues, failure to do so will resulted in fatality if the soil unable to cope with such loading form aircraft when it reaches the runway strip. As this information could be used to predict the settlement or displacement values (cm) whenever different set of weights were imposed on the soil layer. Hence, the settlement values were resulted in this project are due to having different aircraft weights from aircraft of B737, B747 and B777 as a part of input for the simulation. With input such as loading set, CBR values from Dynamic Cone Penetrometer (DCP) test, gear configuration, contact pressure and as well as the wheel spacing. The settlement profile along the Runway Strip are able to be produced and this can be a tool to the airport authority in executing their annual preventive maintenance programme. From the results and analysis done on previous chapters, it is found that the lower CBR values does affect the settlement values to be this highest but it is concluded that among the 3 sets of aircraft weights. In addition, configuration gear in terms of arrangement number of wheels at one axle also contributing the settlement values to be in such variations. This proved by DCP testing results is showing some location with tremendously low values in CBR after calculated. this paper providing layer projection more than 15cm in terms of displacement(cm) compared to as conventionally suggest by ICAO that only suggest strength verification testing and solely depends on CBR values.

# ABSTRAK

Tujuan kajian adalah untuk meramal kekuatan tanah di jalur landasan untuk mempunyai nilai CBR yang dicadang oleh ICAO. Menurut rujukan manual *" Aerodrome Design Manual (Doc 9157 AN/901A)* diterbit oleh *International Civil Aviation Organization* (ICAO) terdapat unsur ketidakpastian dalam melanjutkan lebih daripada 15 cm di bawah dan ia hanya menggambarkan kekuatan CBR tetapi tidak mengambarkan implikasi mempunyai nilai CBR tersebut. Lapangan terbang di seluruh dunia melakukan aplikasi yang sama dalam mengumpul maklumat jalur landasan mereka. Program penyelenggaraan pencegahan diperkenalkan untuk mengurangkan masalah supaya dapat melakukan penambahbaikan kekuatan tanah, kegagalan berbuat demikian akan mengakibatkan kematian jika tanah tidak dapat menampung berat pesawat dalam bentuk muatan sedemikian apabila ia mencapai jalur landasan. Maklumat ini boleh digunakan untuk meramalkan nilai mendapan tanah (cm) apabila setiap set beban yg berlainan jenis berat dikenakan pada lapisan tanah. Justeru itu, nilai mendapan yang dihasilkan dalam projek ini adalah kerana akibat mempunyai berat pesawat yang berbeza seperti dari pesawat B737, B747 dan B777 sebagai sebahagian daripada input untuk simulasi. Dengan input seperti set pemuatan, nilai CBR dari ujian Dynamic Cone Penetrometer (DCP), konfigurasi gear iaitu alatan, tekanan permukaan dan juga jarak roda. Profil nilai pemendapan di sepanjang jalur landasan udara dapat dihasilkan dan ini dapat menjadi alat untuk pihak berkuasa lapangan terbang dalam melaksanakan program penyelenggaraan pencegahan tahunan mereka. Dari hasil dan analisa yang dilakukan, didapati CBR yang rendah mempengaruhi nilai penyelesaian untuk menjadi yang tertinggi tetapi disimpulkan bahawa di antara 3 set berat pesawat. Di samping itu, konfigurasi *gear* dari segi bilangan susunan roda pada satu gandar juga mempengaruhi nilai mendapan berbeza dan tidak seragam. Ini terbukti dengan hasil ujian DCP menunjukkan beberapa lokasi dengan nilai yang sangat rendah dalam CBR selepas dikira. kertas ini menyediakan unjuran lapisan lebih dari 15cm dari segi

anjakan (cm) berbanding yang digariskan oleh ICAO dengan hanya mencadangkan ujian pengesahan kekuatan dan semata-mata bergantung pada nilai CBR.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The purpose of this project report is mainly to go deeper in depth of the evaluation of settlement due to lift condition for airport's runway strip consists of Dynamic Cone Penetrometer (DCP) test for California Bearing Ratio (CBR) values and also model simulation for aircraft B737 and B747 to investigate settlements yields(mm) needed for subsurface information inventory gained to ensure that the strip may function accordingly from further collapsing nose gear or main gear of an aircraft which could results in causing human lives. Not only it can function as indicator of early signs of inadequate strength, it also done so that an optimum plan may be prepared before aircraft components such as nose or main gears fails to stay above ground. Testing should perform to measure the penetration rate, in order to obtain a direct and rapid in-situ evaluation of the structural strength (stiffness) of soil. The rate of penetration is related to in-situ strength which is California Bearing Ratio (CBR).

This project done with site data collection from real case study all over Peninsular Malaysia based on number of blows and converting it into California Bearing Ration (CBR) values and computing model simulation model based of different category of Maximum Take-Off Weight (MTOW) and come up with derivation of settlement yields(mm) values that will be conducted on airport's runway strip.

## 1.2 Problem Statement

The recent incidents happen in Tribhuvan International Airport (NEPAL) on 20th of April 2018 it was closed after a Malindo Airlines aircraft skidded off its runway on that Saturday night carrying 139 people that aborted its takeoff and skidded into mud forced Nepal's Kathmandu airport to shut down for more than 12 hours. However, there is no casualties found. Malindo's Boeing jet B737 skidded into grass and came to a halt in mud about 30m from the runway. Despite veered off the runway, the jet seems managed to stop due to the nose gear only sunk into the mud, close enough to not collapse and the gear components (nose gear and main gear) did not come off the plane which could cause it flew off further.

Even though there are uncommon to have casualties reported in our country, such incident shall be made as benchmark of the worst-case scenario that could happened and causes death. Whenever these happened, none other than drawing attention to airport authorities but also the maintenance team that is responsible in periodically compliance testing on the runway strip.

However, not all incidents of aircraft skidded off the runway and stop at runway strip does not affect human safety. For instance, at Dabolim Airport in Goa,India on 27th December 2016 were once struck with this kind of incidents where a B777 of Jet Airways veered off runway and its caused 15 minor casualties to the passengers.

## 1.3 Objectives

Several constructive objectives of this project report is to highlights a soil strength test called Dynamic Cone Penetrometer (DCP) test as a tool to evaluate strength condition of runway strip in order to fulfilled recommendation by Aerodrome design Manual 3rd edition 2016 from International Civil Aviation Organization (ICAO) to gather the strength information mainly on runway strip acceptance criteria.

Outline of main objectives are as follows;

1. To determine California Bearing Ratio (CBR) values for the runway strip.
2. To produce simulation of settlement yields (cm) based on aircraft type up to 90cm in depth.
3. To determine the location of highest settlement yields (cm) and gives out overview of the whole length runway with surface profile using the proposed 6 points.

## 1.4 Scope Of Project

A thorough runway strip investigation done at a runway strip to identify highest settlement yields(mm) throughout the runway length. In this project, a runway strip located in Peninsular Malaysia were chosen as the fieldwork. It is a state airport with one active runway available for landing, take offs and taxing. Also built with complete runway ends and adequate area to execute a Dynamic Cone Penetrometer (DCP) test.

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